

EVALUATION OF CANCER INCIDENCE IN RAYON PARK

SUMMARY

Chesterfield County Health Department collected information on the occurrence of cancer among 275 current and former residents of Rayon Park representing a period spanning 16 years. Average population of the community was 203 individuals, representing 3,248 person-years of observation. Twenty-six cancers were found to have developed in Rayon Park residents over the 16-year period. The occurrence of cancer in the Rayon Park population was compared to the occurrence of cancer in the entire Chesterfield County population during the same period using two methods. These methods produced Standardized Morbidity Ratios of 1.07 and 1.39, and neither of these ratios was statistically significant. For this period, Rayon Park residents were statistically no more likely to develop cancer than other Chesterfield residents.

Although cancers were not increased overall, cancers of the colon, rectum and lung represented a larger portion of these cancers among Rayon Park residents. However, other cancers possibly associated with volatile organic compound exposure (leukemia, hepatic carcinoma) did not occur in Rayon Park residents during the study period. No association was found between cancers of the colon and rectum among Rayon Park residents and years of well-water use.

To date there have been no exposures identified which would create a health risk to the entire Rayon Park community. If a previous unidentified exposure has taken place, it has not resulted in a statistically significant increased rate of cancer among residents.

INTRODUCTION

Groundwater contamination by volatile organic compounds (VOCs) has been a major concern for the residents of Rayon Park, a community of approximately 109 residential units in Chesterfield County. Activities at the adjacent 640-acre Defense Supply Center Richmond (DSCR), which borders Rayon Park on the south and west, have resulted in soil and underground water contamination by (VOCs), other organic compounds and metals. Since the 1940s, DSCR has provided multiple support functions for the United States Military. **(Reference 1)** Chemical handling, storage and disposal procedures during this period resulted in soil contamination onsite and groundwater contamination of the shallow and deep aquifers under DSCR. In 1984, an onsite environmental assessment identified contamination of the soil and groundwater by petroleum products, chlorinated and nonchlorinated solvents, pesticides, herbicides and metals. Plumes of multiple materials were identified in both upper and lower aquifers, extending east from DSCR, north of the Rayon Park area. **(Figures 1-4)** The site was designated to the Environmental Protection Agency (EPA) Superfund list in 1987. In 1993, the Agency for Toxic Substances and Disease Registry (ATSDR) reported that no adverse health effects were expected from the superfund site. **(Reference 2)** By the year 2001 the plumes in the upper and lower aquifers had moved east, but were still centered northwest of Rayon Park. The outer limits of the plumes did not intrude into the Rayon Park area.

(Figures 3-4)

In May 2001, residents of Rayon Park met at a private residence with their elected representative and the Chesterfield County Health Director to express their concerns regarding malfunctioning septic systems, the need for county sewer connection, and what they believed to be a large number of cancers and other diseases among neighborhood residents. Residents in

Rayon Park believed they might have a higher than average cancer incidence due to possible soil and groundwater contamination by VOCs (trichloroethylene, benzene and toluene) and other suspected, but unidentified, carcinogens. At that point the Chesterfield County Health Director committed the department to study the issue of cancer incidence. The purpose of this study is to determine whether Rayon Park has a rate of cancer higher than the rest of the county and to determine if any exposures/risk factors might be associated with the suspected higher rate.

EXPOSURE INFORMATION

Until 1985 the drinking water source for most residents was a private underground well. In 1985, connection to the public water supply began and by 1987 most residences had connected to the public water supply. Between 1982 and 1987, eighteen private wells were sampled every two months for volatile organics. **(Reference 3)** With the exception of five addresses on Fonda Street and Alcott Road in the northwest corner of Rayon Park, all the results showed only intermittent elevation of random volatile organic chemicals such as benzene, chlorobenzene, 1,1-dichloroethane and tetrachloroethane. All of these elevations were small (between 0.2 parts per billion and 2.4 parts per billion). One address showed a temporary elevation of toluene. Toluene was not detected at this site before or after that sampling. The most common material detected was chloroform in trace amounts, with occasional elevations within safe drinking-water limits. A single address reached the safe drinking-water limit for chloroform once in the three-year period. In all cases, detection of these materials has been sporadic and at low levels not known to cause adverse health effects.

Between November 1985 and January 1987, increased levels of 1,1,1-trichloroethane (from 15 – 500 µg/L), 1,1-dichloroethene and 1,1-dichloroethane were detected in one of the

sampled private wells on Fonda Street. Peak levels of these substances were reached between November 1985 and May 1986 and declined thereafter. Adjacent wells on Fonda Street and Alcott Road showed similar elevation and decline of the same chemicals during this period, although the highest concentrations appeared to be separated from the DSCR property by private wells with lower concentrations. Other than this exposure, there is no evidence that residents have been exposed to volatile organic chemicals in their well water at levels known to cause cancer or other adverse health effects.

Health effects of contamination in No Name Creek, which runs through DSCR and then through the eastern portion of Rayon Park, were also previously assessed. In 1993, ATSDR studied the issue of possible exposure to well water and creek water, and determined they did not present a significant health risk. (**Reference 2**)

METHODS

This cancer cluster study involved the neighborhood of Rayon Park in Chesterfield County, Virginia, and included those persons residing in Rayon Park between 1985 and 2000. Between June 19, 2001, and October 24, 2001, a house-to-house survey was conducted to obtain information on the various characteristics of the population. The variable fields obtained were sex, age, length of residence (past or current residency status), history and year of cancer diagnosis, site of diagnosis, sources of water supply for the duration of residence, total years of well-water use, family history of cancer, history of chronic illness, history of alcohol consumption and total years of drinking (present or past), history of tobacco use and total years of smoking (present or past) and employment history. The main outcome variable was development of cancer at any time during the study period. All resident-reported cases of cancer

were verified using the Virginia Cancer Registry (VCR). Resident-reported cases not found in the VCR were verified as having cancer by either medical records or death certificates.

Information on past/deceased residents was obtained through interview or proxy. Out of the total number of 339 residents who were identified, 64 were excluded for having taken up residence after December of 2000 or having moved out of Rayon Park prior to 1985. Residents who never resided in Rayon Park during the study period (1985 – 2000) were excluded from the study.

ANALYSIS

Age and gender of the Rayon Park population were collected and compared with the county population.

The cumulative cancer-incidence rates were age-adjusted by applying stratum-specific incidence rates obtained from the reference population (i.e., Chesterfield County population) to the study population (i.e., Rayon Park) using the 1993 (mid-point of the study period) populations. The assumption was made that the population of Rayon Park was stable throughout the study period. An estimated population of Rayon Park, based on the total number of residents surveyed who were in residence in December 2000, was used as an approximation of the 1993 Rayon Park population. The 1993 population for Chesterfield County was obtained from the Chesterfield County Planning Department. The expected number of cancer cases for each stratum was then calculated. The summary standardized morbidity ratio (SMR) was obtained using the formula:

$$\text{SMR} = \text{Observed cases (O)} / \text{Expected cases (E)}.$$

A test of the null hypothesis that Rayon Park residents had the same cancer incidence rate as the Chesterfield population is obtained by referring the statistic $X^2 = (O - E)^2/E$ to a chi-squared

distribution with one degree of freedom. Ninety-five percent confidence intervals (CI) were calculated around the SMRs. A CI that included 1.0 was not considered statistically significant.

SMRs were computed two ways. The first, and most statistically correct, was to use only Virginia Cancer Registry data to compare cancer incidence in Rayon Park to cancer incidence countywide. This approach reduced the bias inherent in using citizen-reported cancers in Rayon Park, but not using citizen-reported cancers countywide. The second SMR was calculated using **all** the self-reported cancers occurring in the Rayon Park study period that were verified, including those that were not reported into the Virginia Cancer Registry. This technique introduced significant bias toward determining an effect in Rayon Park since it is impossible to survey the entire county for self-reported cases and include them. However, it was felt that the most conservative approach possible should be pursued.

Because the summary SMR might provide an inadequate overall summary of the rate ratios in each age group, the age-specific SMRs were also computed.

To determine the association between the predictor variables and cancer incidence, Cox regression modeling was used, with an “event” defined as cancer diagnosis and the “time” variable as age. The exposure variables were sex, total years of well-water use, family history of cancer, total years of cigarette smoking, current and past cigarette packs per day, total years of alcohol consumption and current and past amounts of drinks per week. Sex and family history of cancer were coded as categorical variables, while total years of well-water use, cigarette smoking (years smoked and packs smoked per day) and alcohol use (years of drinking and drinks per week) were entered into the regression model as continuous variables. Statistical analysis was done using SPSS version 10.0.

RESULTS

The estimated 1993 population for Rayon Park was 204 and that for Chesterfield County was 225,603. The age group of 50 and older represented a larger proportion of Rayon Park residents than county residents. **(Table 1)** The total number of verified cases of cancer within residents in the Rayon Park community between 1985 and 2001 was 26. **(Table 2)** Twenty cancer cases were verified using the Virginia Cancer Registry and six were verified from medical records or death certificates. About 58% of the cancer cases were in men. The leading site for cancer identified in Rayon Park was colon/rectum. This site accounted for 31% of all the cancers. **(Figures 5-7)** Other leading sites for cancer were lung/bronchus (19.2%) and prostate (11.5%). Comparatively, the leading sites for cancer in Chesterfield County were breast (20%), lung/bronchus (13.7%), prostate (13.4%) and colon/rectum (11.0%). The cancer cases identified in Rayon Park had a mean age of 68, standard deviation of 13.33, with a range of 54 (minimum = 36 and maximum = 90). **(Figure 8)** Chesterfield cancer cases had a mean age of 59.2 (standard deviation = 16.33). The range was 103 (minimum = 0 and maximum = 103). **(Figure 9)** This age difference is not statistically significant.

Comparing only cases reported by the Virginia Cancer Registry produced a Standardized Morbidity Ratio of 1.07 with a 95 % CI of 0.65 to 1.65. **(Table 3)** This indicates that the residents of Rayon Park are no more likely to develop cancer than other county residents.

Comparing all reported cases in Rayon Park to only Virginia Cancer Registry cases in Chesterfield County produced an SMR for Rayon Park of 1.39, with a 95% CI of 0.91 to 2.03. **(Table 4)** The chi-squared value of 2.80 had a p-value > 0.05, indicating that the difference is not statistically significant.

The age-specific rate ratios showed that the cumulative cancer incidence rates in the various age groups in Rayon Park were not significantly different from that of Chesterfield County.

The total number of residents (past or current) included in the regression analysis was 275. No association was shown between developing cancer and gender, family history or well-water well use.

The exposure variables that showed any statistically significant association with cancer incidence were total years of cigarette smoking and total years of alcohol use. (**Table 5**) The risk ratio (RR) associated with a unit increase in years of cigarette smoking was 1.03 (95% CI 1.01 – 1.06). For alcohol use, a unit increase in years of consumption had a risk ratio of 1.04 (95% CI 1.01 – 1.08). Total years of well-water use did not show an association with cancer incidence.

DISCUSSION

The findings of this study are that the cancer incidence rate in Rayon Park is not significantly different from the Chesterfield County rate when adjusted for age. There also is no association between cancer and duration of well-water use. The analysis, however, shows duration of cigarette smoking and alcohol consumption to be positively associated with the cancer cases identified in Rayon Park. This association is already well known. For cigarette smokers, every year of smoking carries a 3.0% increase in risk for cancer development (p-value = 0.015). Every one-year increase in alcohol consumption is also associated with a 4.4% increase in cancer risk (p-value = 0.026). A 20- and 30-year history of cigarette smoking would have relative risks for cancer development of 1.79 (95% CI 1.12 – 2.86) and 2.39 (95% CI 1.18 –

4.83) respectively. For similar duration of alcohol consumption, the cancer-relative risks would be 2.36 (95% CI 1.12 – 4.98) and 3.63 (95% CI 1.29 – 11.10) respectively.

A comparison of cancers by site shows only nine different cancers for Rayon Park and 23 for Chesterfield County. **(Table 2)** The leading sites for cancer in Chesterfield were breast (19.9%), lung (13.7%), prostate (13.4%) and colon/rectum (11.0%). In Rayon Park, the leading cancer site was colon/rectum, accounting for 31% of all the cancers identified (95% CI of 15 % - 52%). The chi-squared test of significance did not show any association between colon/rectal cancers and total years of well-water use ($\chi^2 = 15.4$, $df = 14$, and $p\text{-value} = 0.35$).

It is well established that cancers have multiple causes. Many of the risk factors for cancer are determined by individual behaviors, such as smoking, diet, sun exposure and low fiber diets. Other risks are determined by circumstances that cannot be controlled, including a person's genetic predisposition to cancer and the random chances of an adverse event. Other than lung cancer, the underlying causes are often never determined. Overall, the chances that a citizen will have a personal encounter with cancer are high. In Virginia, cancer is the second leading cause of death, with 13,481 fatalities in 2000.

Although significant contamination of the private water wells in Rayon Park was not found, and no other route of exposure appears likely, a literature review was conducted to evaluate what types of cancer would be caused if a hypothesized exposure were to occur. The materials of greatest concern are tetrachloroethylene, trichloroethylene (TCE) and benzene.

- Benzene is a mutagen and has been shown to cause myelogenous leukemia in humans **(Reference 4)**. In the Rayon Park study, no cases of myelogenous leukemia were found.
- In lifetime animal bioassays, trichloroethylene (TCE) has been shown to cause liver tumors in mice following gavage, liver and lung tumors in mice following inhalation, and

kidney tumors in rats following gavage or inhalation. **(Reference 5)** It is not carcinogenic in the rat lung. **(Reference 6)** Human evidence regarding the carcinogenicity of TCE is limited. A 2001 study that looked at cancer incidence among Danish workers exposed to TCE found no overall increase in cancer risk. **(Reference 7)** The authors reported significantly elevated standardized incidence rates (SIR) for non-Hodgkin's lymphoma (SIR = 3.5) and cancer of the esophagus (SIR = 4.2) in men and cervical cancer (SIR = 3.8) in women. **(Reference 6)** They could not come out with any definitive conclusions about etiology due to the small numbers of observed cases and the lack of dose-response relationship. In the 16-year Rayon Park study period, there was one case of esophageal cancer and no cases of non-Hodgkin's lymphoma.

- A 1999 population-based, case-control study to evaluate the relationship between cancers of the colon/rectum, lung, brain, and pancreas and exposure to tetrachloroethylene (perchloroethylene or PCE) provided evidence for an association between PCE-contaminated public-drinking water and cancer of the lung, and possibly cancer of the rectum. **(Reference 8)** PCE was until recently a common dry-cleaning agent and is a common environmental contaminant. However, this association was found only for individuals exposed to high levels of contamination in the range of 800-18,000 parts per billion. PCE in Rayon Park wells has not been detected at anything but trace levels, and levels of high magnitude such as this would not have escaped detection.
- A study in 2000 examining human variability and susceptibility to trichloroethylene appeared to demonstrate an excess risk of breast and cervical cancers among women exposed to TCE. **(Reference 9)** Breast cancers were a smaller proportion of overall

cancers in Rayon Park than they were in the county population, and there were no cervical cancers in the study period.

STUDY LIMITATIONS

Some limitations of this study deserve mentioning.

- The estimate of the 1993 Rayon Park population and the age distributions might not have been precise. However, they appear to be the best estimates available.
- Comparing countywide estimated rates from the Virginia Cancer Registry to observed Rayon Park rates introduces bias in favor of detecting an increased cancer rate in Rayon Park. Six of the 26 confirmed resident-reported cancer cases in Rayon Park were not reported to the Virginia Cancer Registry. This would indicate that cancer cases countywide are under-reported, perhaps by as much as 23%. This underestimates the actual morbidity rate for the county, and, therefore, the expected rate for Rayon Park. The study identifies these unreported cases in Rayon Park, alone, and, therefore, the study rate more closely approximates the real rate. With this method, the magnitude of the standardized morbidity ratio is artificially increased. Although flawed, this approach was used since it was more likely to detect an effect if one exists.
- The retrospective nature of the study might have introduced some bias in residents' recall of events.
- Working with small numbers makes interpretation of study findings difficult.

CONCLUSION

Overall cancer incidence among residents of Rayon Park is not increased when age is taken into account. The exposure variables that showed any association with development of cancer were total years of cigarette smoking and total years of alcohol use. There was no association between cancer and private-well-water use. Although cancers of the colon, rectum and lung represented a higher proportion of overall cases in Rayon Park residents, other cancers commonly associated with chemical exposure, such as lymphoma, leukemia and hepatic cancers, did not occur. There was no association between cancer of the colon/rectum and years of well-water use. These findings indicate that a resident of Rayon Park is no more likely to develop cancer than any other resident of Chesterfield County who is the same age.

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Figure 1

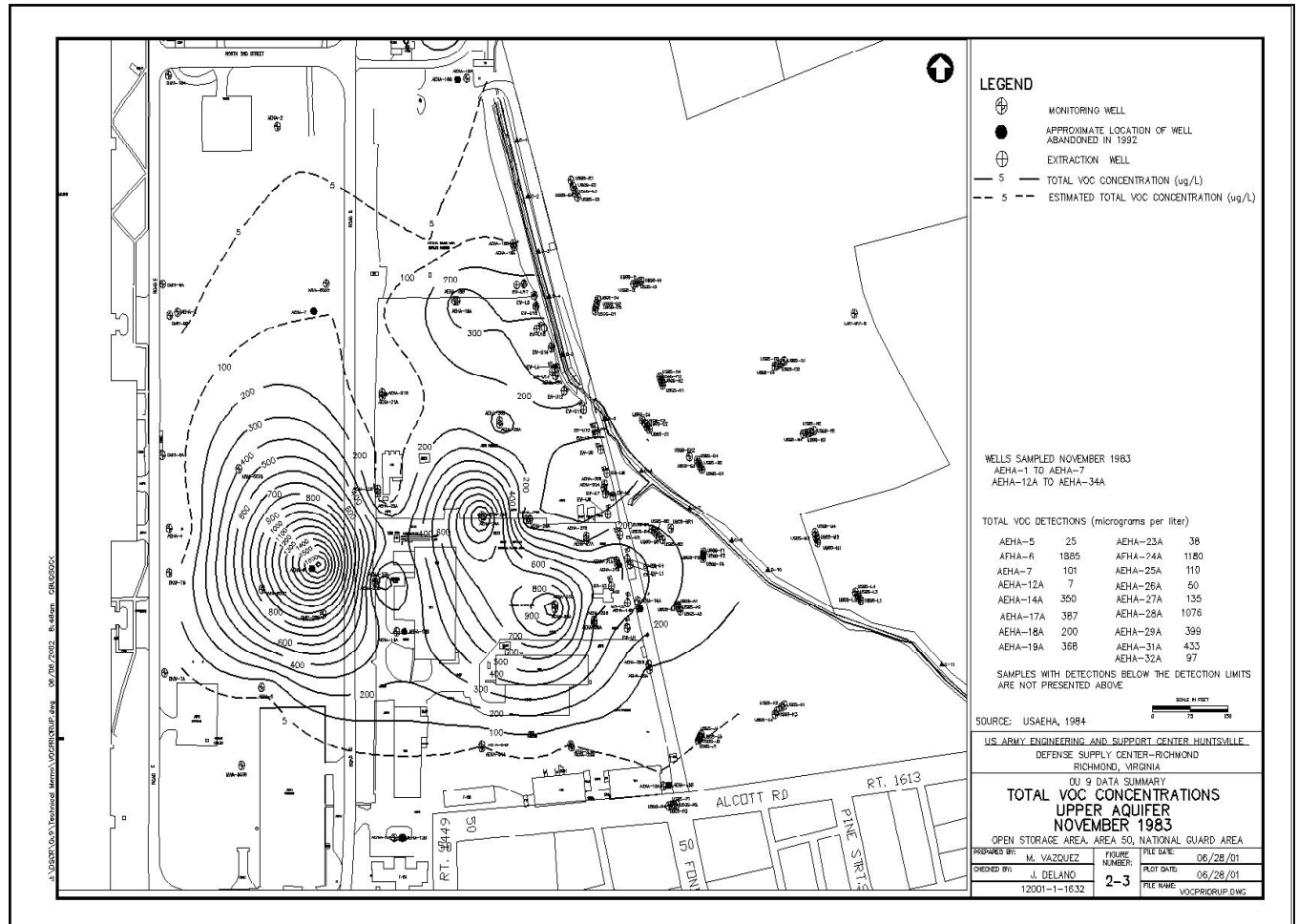


Figure 2

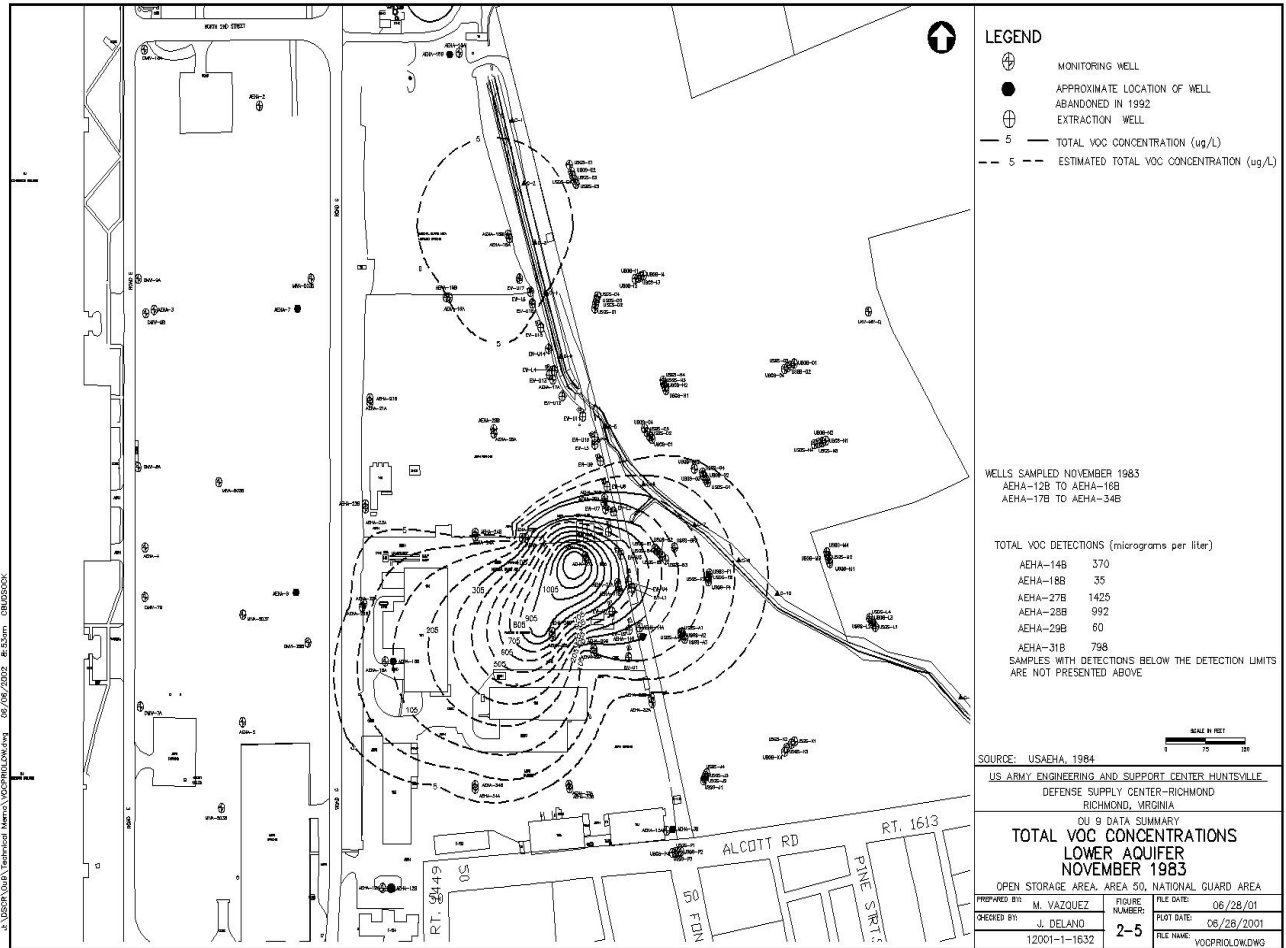


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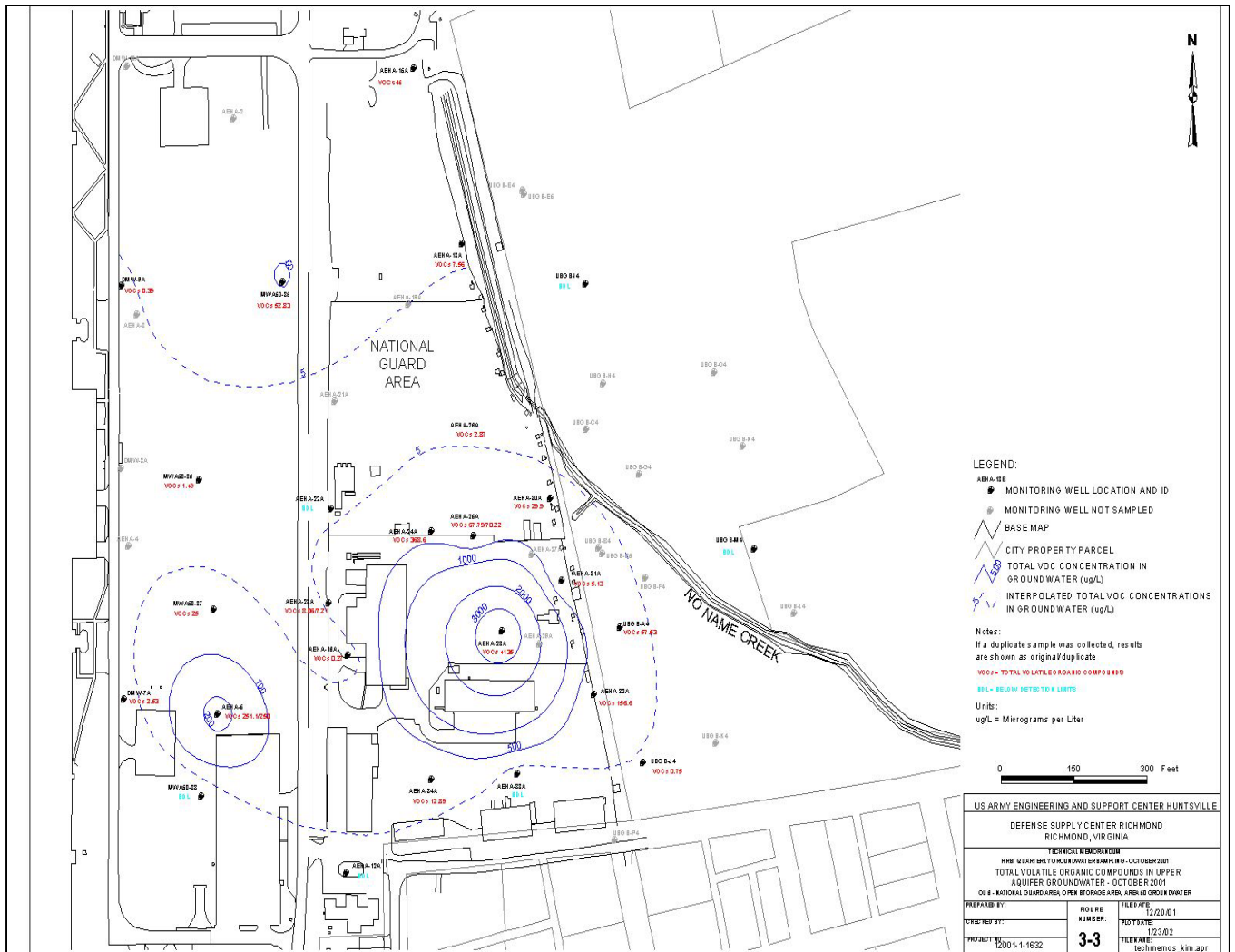


Figure 4

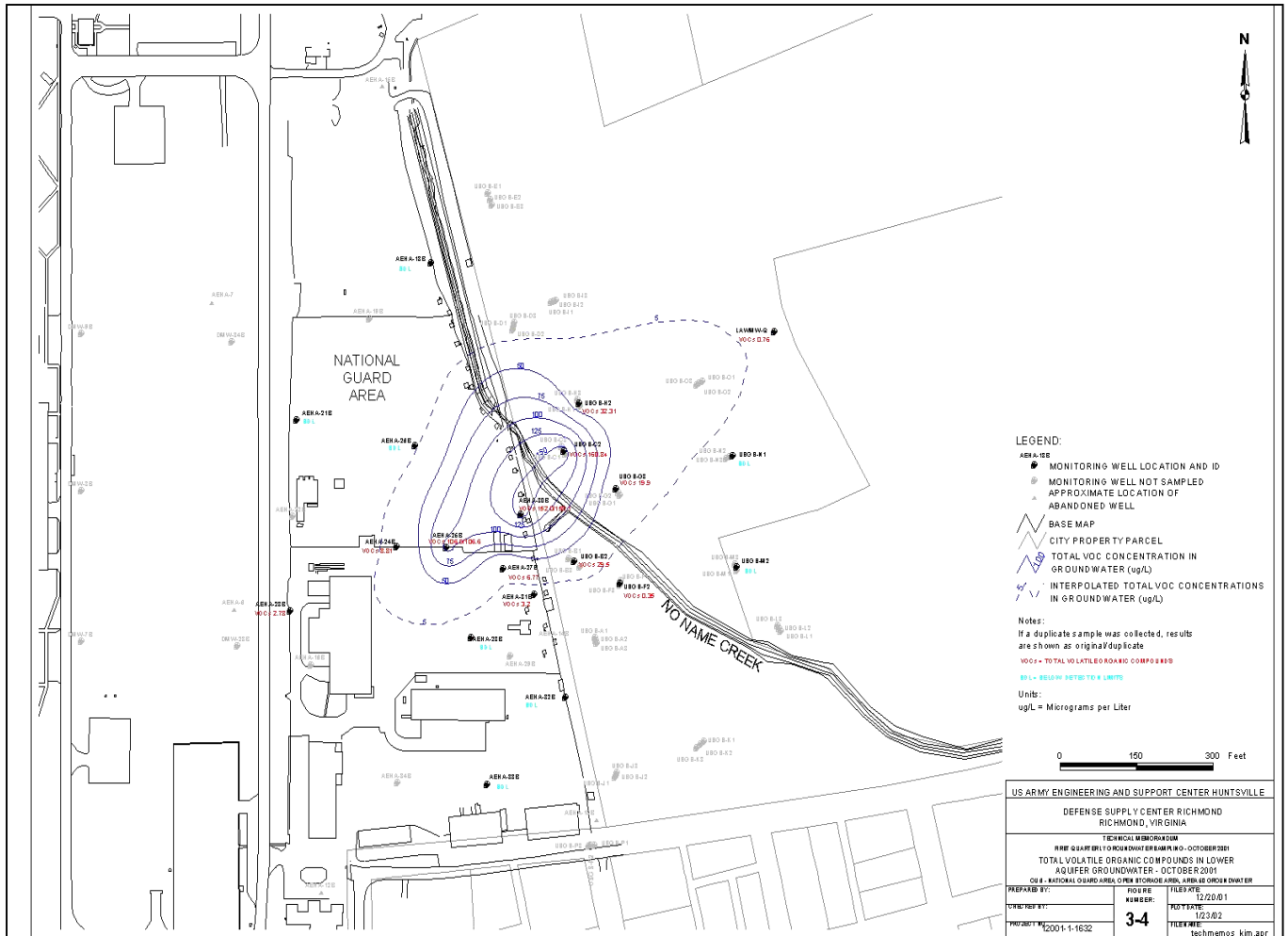
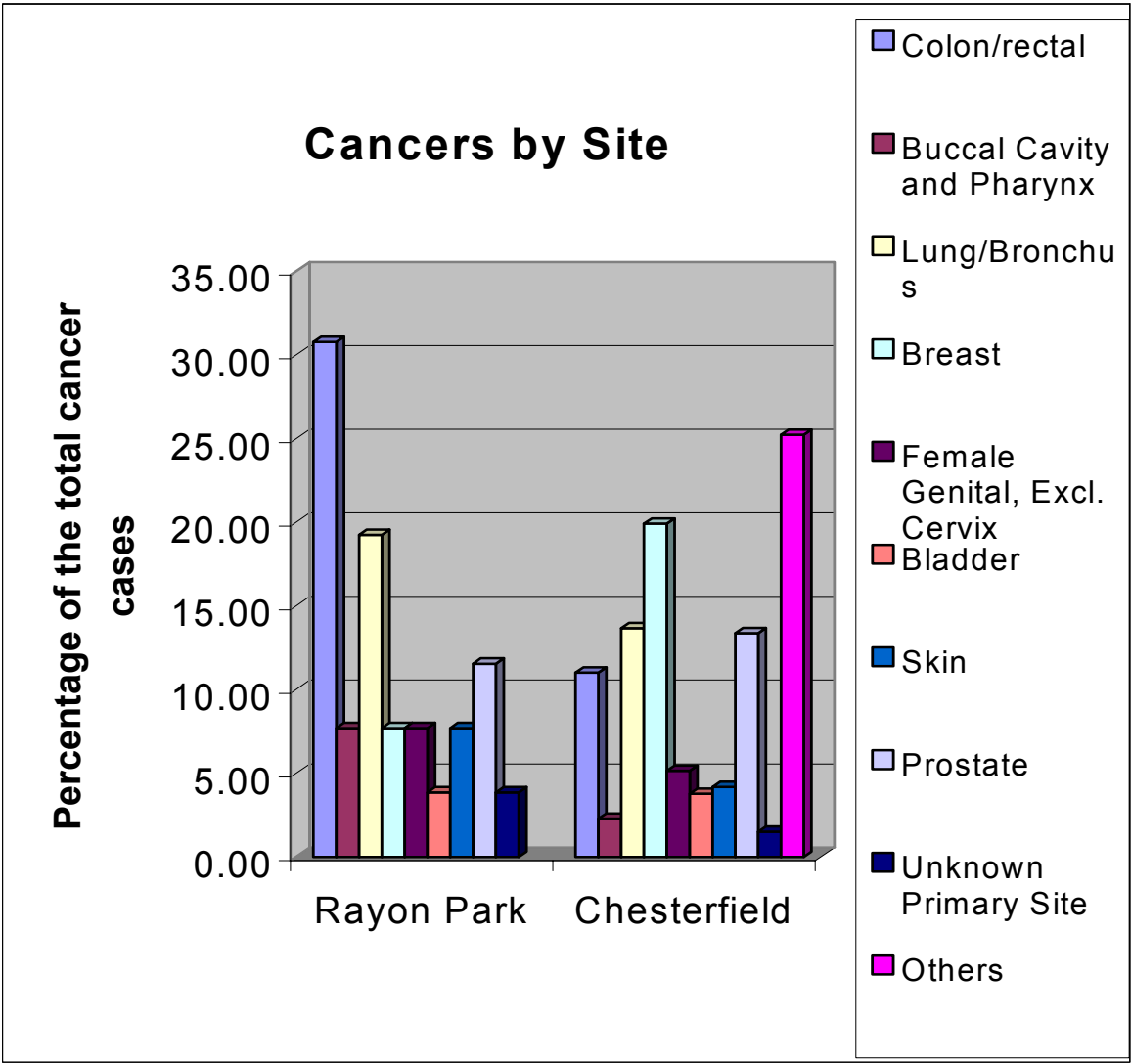


Figure 5.

Rayon Park and Chesterfield County Cancers by site



“Others” refers to all the other different types of cancers found in Chesterfield, but not in Rayon Park.

Figure 6

Rayon Park Cancers by site

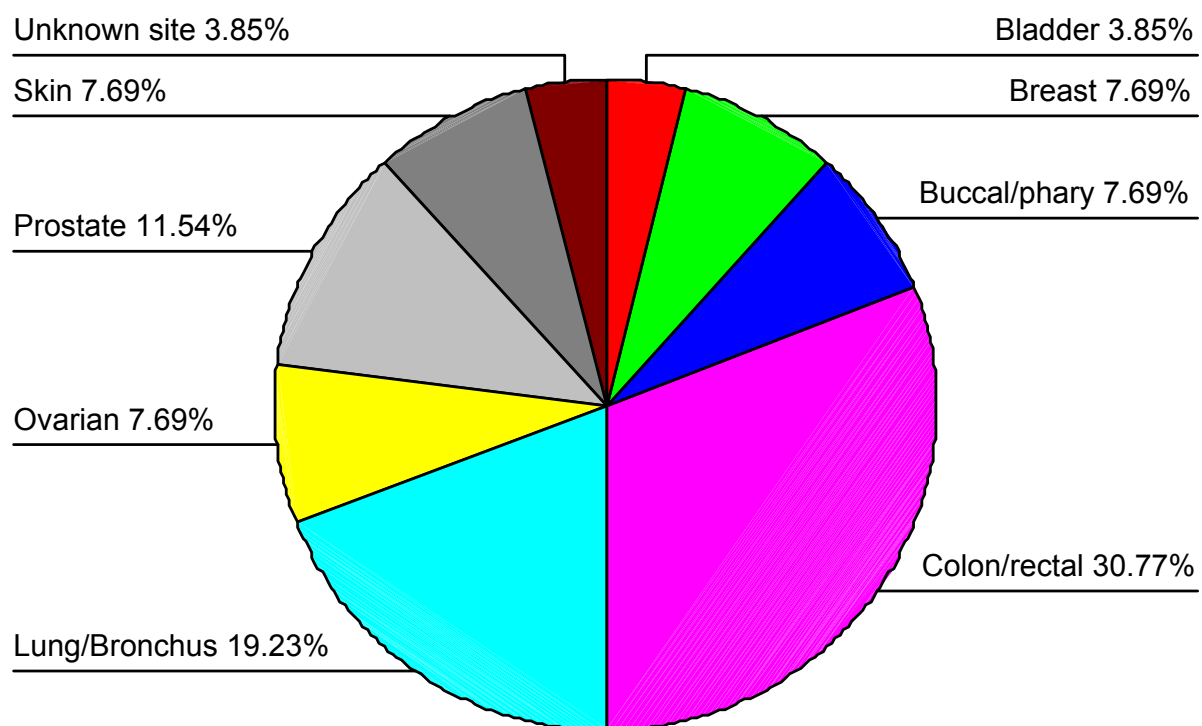


Figure 7

Chesterfield Cancers by Site

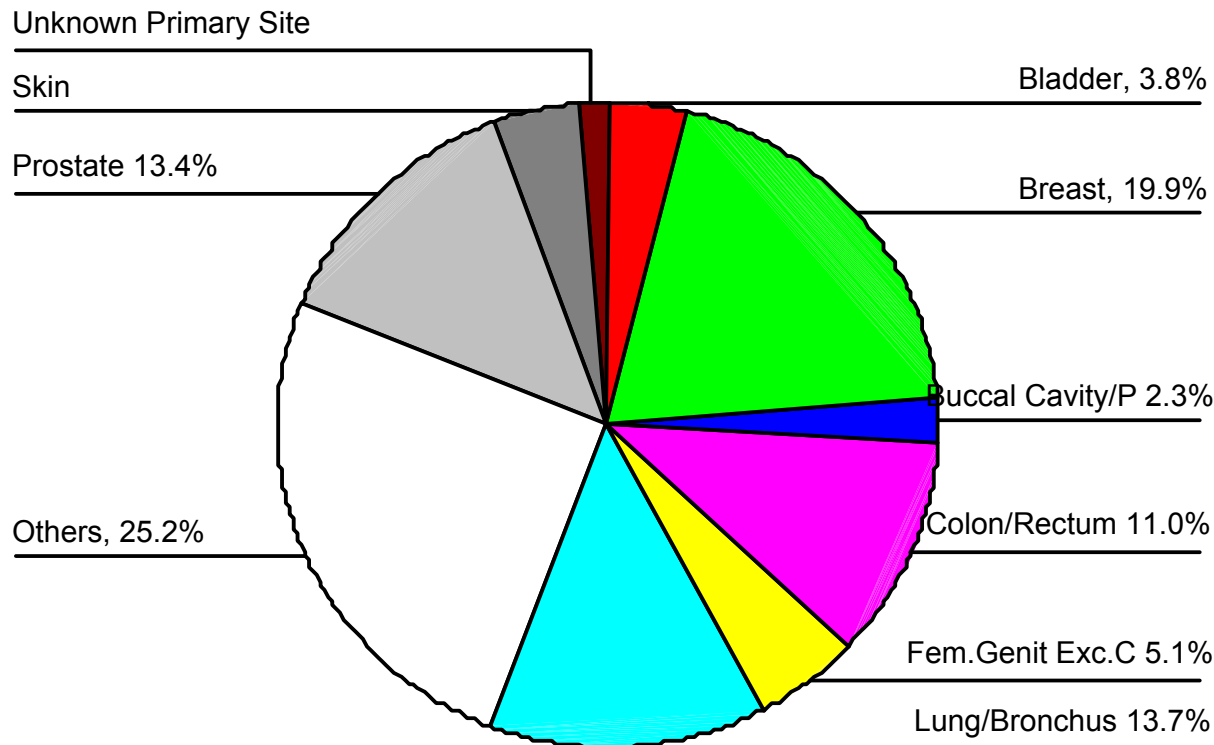


Figure 8

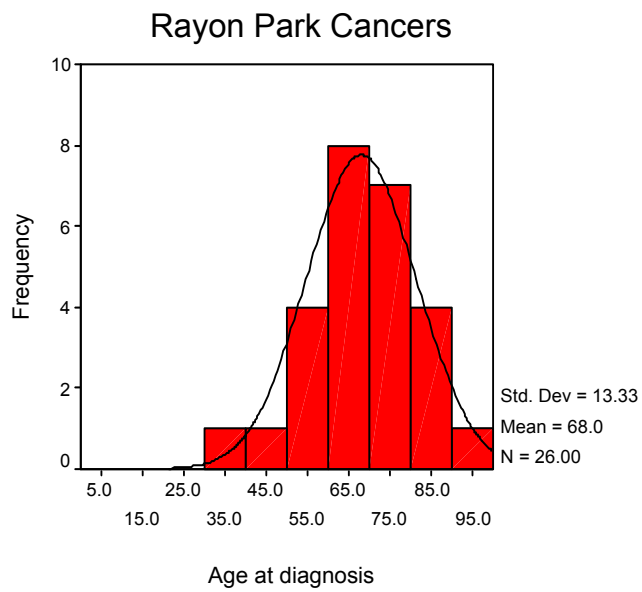


Figure 9

